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MINING METHODS AND COSTS AT THE HART SPUR PIT OF THE FORT WORTH SAND & GRAVEL CO. (INC.), FORT WORTH, TEX.

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THOMAS E. POPPLEWELL

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MINING METHODS AND COSTS AT THE HART SPUR PIT OF THE FORT WORTH SAND & GRAVEL CO. (INC.), FORT WORTH, TEX.[1]

By Thomas E. Popplewell[2]

INTRODUCTION

This paper is one of a series being prepared for and published by the United States Bureau of Mines describing the mining and treatment methods and costs obtained in sand and gravel plants throughout the United States.

These papers are designed to disseminate technical information regarding the methods used. The cost tabulations represent operating expenditures only and not total costs. It is recognized that publication of total costs might in many instances cause embarrassment to individual operators as well as to the industry as a whole. On the other hand operating costs are essential to the technical discussion and study of the methods employed. The attention of the reader is specifically called to this differentiation in order that no misunderstanding of the scope of the cost tabulations shall ensue.

The methods employed at the Hart Spur pit of the Fort Worth Sand & Gravel Co. are described in this paper. The pits are located along the Trinity River, from Fort Worth eastward to the Tarrant County line, and are adjacent to the Rock Island Railway Co.'s tracks, to which the standard-gage gravel-pit track is connected at Hart Spur.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the assistance of the Bureau of Economic Geology of the University of Texas and the suggestions of J. R. Thoenen of the United States Bureau of Mines, in the compilation of this report.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6652."

[2] One of the consulting engineers, U. S. Bureau of Mines, and secretary, Fort Worth Sand and Gravel Co. (Inc.).

HISTORY

When sand and gravel were first used for building roads and concrete structures in this vicinity, the pits were operated by hand and deliveries were made by wagon from pits that are now within the city limits of Fort Worth. The company is still working a number of these pits as one unit, although its operations now extend down the Trinity River about 15 miles. In 1919, the company opened the first machine-operated gravel pit in the county and produced pit-run concrete gravel for the building trade. In the following year it built a small gravity washing and screening plant in order to make a product that would compete with crushed stone. The progress made in the design and control of concrete for specific purposes has created such a demand for better graded and washed materials that the company has been forced to remodel old plants and to build additional ones of modern type.

GEOLOGY

Two types of gravel deposits are found in Tarrant County: (a) River gravel, which is found in the lowlands and consists of rounded clean pebbles and sand with little or no cementing material; and (b) pit gravel, which is found in the upland or earlier river bottoms and consists of angular, flat, elongated particles mixed with clay and other foreign matter and particularly with plastic clay balls. The surface over both types of deposits is generally level. The upland gravel deposits are usually the thicker and have heavier overburden; otherwise the two types of deposits are quite similar. These deposits of sand and gravel were washed down the Trinity River from disintegrated medium-hard limestones upstream. As might be expected the larger-sized pebbles were deposited first and the smaller sizes were washed on downstream. The deposition of the material seems to have been caused by the interference of small tributaries, as the deposits are almost invariably found on the upstream side and immediately adjoining the mouths of the small streams. (See fig. 1.) The deposits vary in size from a few acres to over a hundred acres and exist mostly on the north side of the river - a fact which has never been satisfactorily explained.

By mining upland and river gravels at the same time with separate draglines the two can be mixed in the washing plant with good results. A sandy soil and clay varying in thickness from 3 to 8 feet coveres the deposits, which vary from 8 to 25 feet in thickness. In the river deposits water is found from 6 to 8 feet below the surface. This enables the operator to produce a relatively clean pit-run gravel, containing only about 1 per cent clay and silt. Some deposits have a natural grading which permits the use of this pit-run material in making concrete for small jobs, such as residence foundations, sidewalks, and street-paving base where asphalt topping is applied. The deposits are rather free from conglomerate (particles of sand and gravel cemented with free lime from the pit water) except at the water level.

The deposit at Hart Spur consists largely of river gravel, but there are some adjacent upland gravels. At the time of this report the river gravel only was worked.

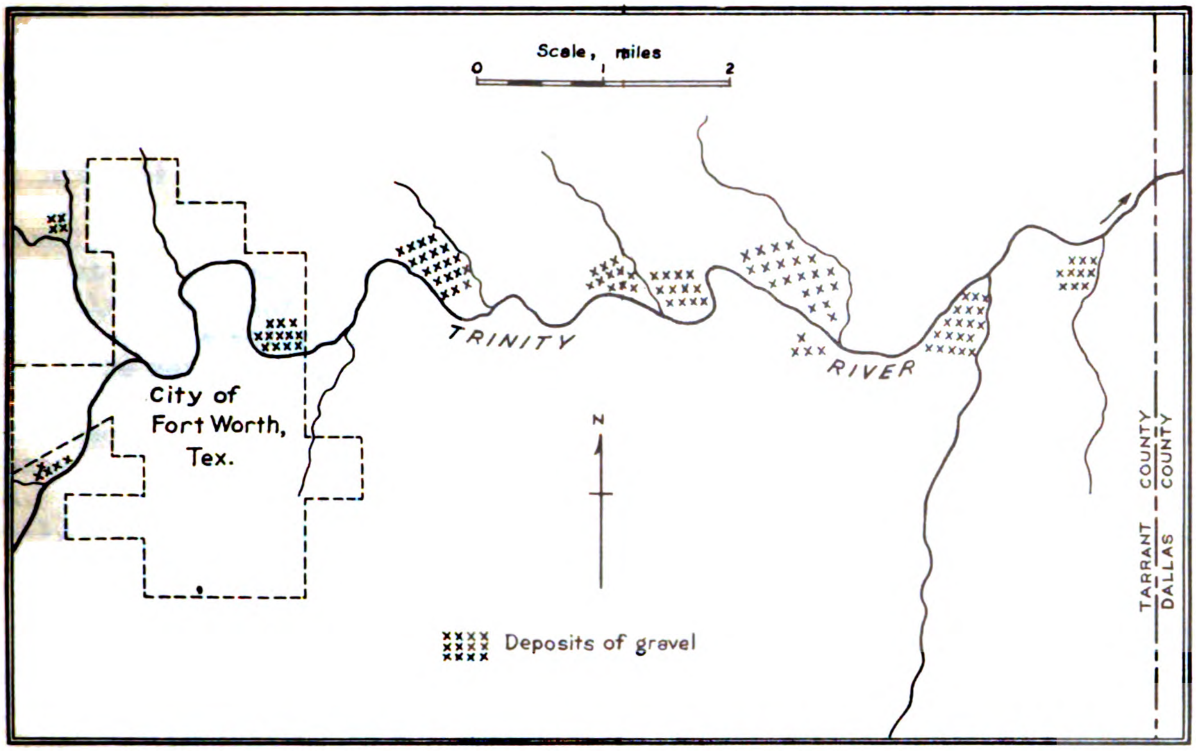

Figure 1.- Sketch showing gravel deposits along the Trinity River, Tex.

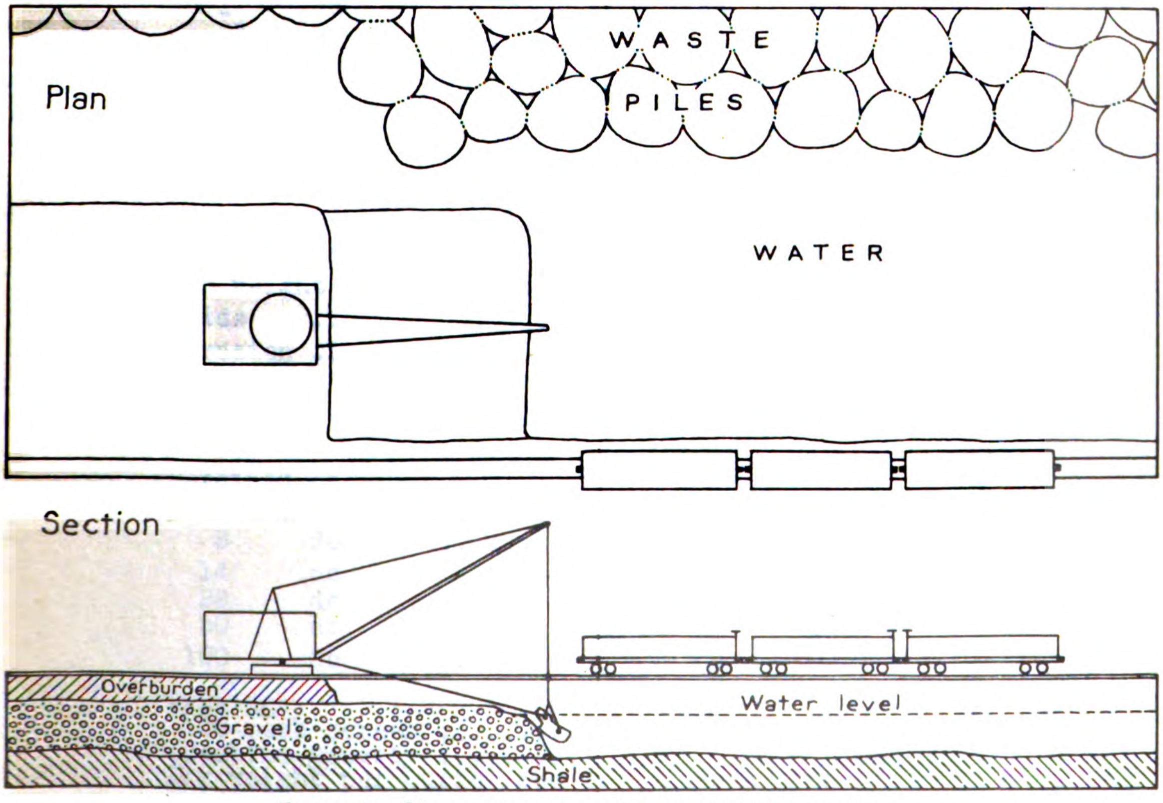

Figure 2.- Plan and section of typical pit operation

PHYSICAL CHARACTERISTICS

Under the top soil which is about 2 feet deep, clay 3 to 8 feet thick overlies the gravel deposit. This overburden forms about 40 per cent of the total material handled, and is cast back into the pit made by previous excavations. The sand and gravel bearing stratum is from 8 to 25 feet deep and is usually underlaid by blue shale. The gravel deposits vary in size and shape, but the average size of commercial deposits is about 70 acres and they are usually triangular in shape - a fact that is accounted for by the deposition of the material on the upper side of the tributaries and between them and the main river. The material is loose and runs approximately 40 per cent of sand and 60 per cent of gravel. The sand and smaller sizes of gravel are siliceous, whereas the larger gravel is mostly limestone. Structurally the sand and gravel is sound, but occasional flat, elongated "floaters" are found. These floaters amount to about 1 per cent of the gravel in the upland deposit, and being soft they increase the amount of abrasion shown by tests. The floaters found in the river gravel are negligible.

ANALYSIS OF MATERIAL AFTER WASHING

Limestone gravel

Retained on:		
3-inch screen	per cent	0.00
2 do.	do	2.1
1½ do	do	5.4
1¼ do	do	9.4
1 do	do	21.1
¾ do	do	48.6
½ do	do	81.1
¼ do	do	98.0
Passing:		
¼-inch screen	do	2.0
Specific gravity		2.61
Dry weight per cubic foot	pounds	96
Voids	per cent	41
Abrasion	do	12

Siliceous sand

Retained on:		
4-mesh screen	per cent	3.0
8 do	do	25.0
14 do	do	40.0
28 do	do	54.0
50 do	do	90.0
100 do	do	99.5
Passing:		
100-mesh screen	do	.5
Specific gravity		2.65
Dry weight per cubic foot	pounds	105
Voids	per cent	36

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PROSPECTING, EXPLORATION, AND SAMPLING

Prospecting and exploration is begun in areas near outcrops of a gravel-bearing stratum, usually in creek banks and in the bottom lands near willow trees, which commonly grow above the gravels in this section. The first testing is done with a regular 8-inch post-hole auger, fitted with an extension handle so that a depth of 10 or 12 feet can be reached. This preliminary work does not indicate the quantity or the quality of the material or the depth of the gravel stratum, but it serves to outline the deposit and determine how much overburden must be removed. Sometimes holes are sunk more or less at random, but they are generally spaced in rows at right angles and distanced roughly in multiples of 100 feet.

If the results of the preliminary investigation justify it, the area to be tested is staked off in checkerboard fashion at intervals of 100 feet. At every third stake a test pit 3½ by 8 feet is dug to the top of the gravel stratum and is continued as a round hole about 3½ feet in diameter to the bottom of the gravel or until water is struck which prevents sinking further by hand. It is not important to reach the bottom of gravels below the water level because experience has shown that the material under water is better than that above it. However, if the gravel stratum above the water is thin it becomes necessary to sink through the gravel in order to estimate the quantity of material in the deposit. A small orange-peel bucket is used inside a 20-inch casing to continue the digging below water level. This bucket is handled on a small crane and is operated by hand. However, if there is as much as 6 feet of gravel above water, the hole is deepened by hand for 2 feet below water level and the excavation is stopped. After reaching a profitable depth it is not important to determine lower extent of the gravel, for only an approximate average bottom can be determined at best, as it will often dip or rise irregularly in the 300 feet between pits.

The test pits are platted, showing the depths of overburden and of gravel, and from this data the extent and approximate yardage of the deposit is calculated. Notations are made on the plat showing the quality of material in each test pit.

The overburden is piled to one side of each test pit and kept separate from the gravel. If the character of the gravel changes from top to bottom, then the different kinds of material are piled separately so that a sample can be taken from each pile. A screen analysis is made of each of these samples, which, after being separated into gravel and sand, are mixed in proportion to the thickness they represent. This composite sample is sent to the State Testing Laboratory for a report on the apparent specific gravity, abrasion, absorption, voids, screen analysis and weight per cubic foot. The results furnished by the State Laboratory are checked by the company and if there is much variation an independent testing laboratory is consulted and further sampling of the deposit may be undertaken.

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The cost of digging test-pits varies with the hardness of the ground. There is little caving of the sidewalls, except below the water line. Post holes cost approximately 10 cents per foot and the test pits about $1 per foot of depth.

CHOICE OF METHOD

The dragline was chosen as the best means of excavation, for the following reasons: (1) The deposit is shallow, the average depth to the bottom of the gravel being 20 feet; hence, frequent moving of excavating equipment is required; (2) 4 to 10 feet of the deposit is below water level; (3) the railroad tracks and hauling equipment required for delivery to the washing plant could be installed and maintained with minimum difficulty; and (4) there is not enough dependable water to operate a pumping plant.

The overburden amounts to about 40 per cent of the total material handled and is easily removed without dilution of the sand and gravel below. Trees sometimes grow over the deposits. If there are many of them, or if they are large, it is necessary to cut them down before commencing excavation, but if they are small they are removed by the dragline along with the overburden. This overburden is cast back into the open pit which has just been excavated. The accompanying plan of tracks and pit operation (fig. 2) shows the method used.

STRIPPING

Stripping is ordinarily done intermittently by the same dragline that does the loading and requires about 40 per cent of its digging time. The dragline will strip off a "set up" (the area reached by the bucket without moving the machine), and then proceed to load the gravel and sand into cars before moving down the track to the next set up. The overburden is usually wasted. Occasionally, however, the railroads will use it for making fills or repairing washouts, but less than 2 per cent of the overburden is sold.

EXCAVATION

A skid-and-roller type and a walking-type dragline are used for both stripping and loading. The former is steam operated and is equipped with a 100-foot boom and a 4½-cubic yard bucket. It has a 120-hp., locomotive-type boiler with 176 two-inch tubes. Oil is used as fuel and is pumped from the locomotive tender to the dragline as required. The locomotive takes oil from the main storage tank located at the washing plant. Water is pumped to the dragline boiler from an abandoned pit in which the water has cleared by a 5-hp. gasoline engine directly connected to a 2-inch centrifugal pump. It is conveyed to the dragline by a 2-inch pipe line laid on top of the ground along the railroad track. This dragline uses 140 feet of 1-3/8-inch, 6-strand, 19-wire, Lang-lay cable with independent wire-rope center as a drag cable. The life of the cable is approximately three months. For hoisting, a 6-strand, 19-wire, regular lay, hemp-center 7/8-inch cable 440 feet long is used. This cable lasts approximately eight months under average conditions.

The walking-type dragline is powered by a 120-hp., 2-cylinder Diesel engine with 16-inch stroke and bore, operating at 260 r.p.m. and equipped with a 70-foot boom and a 3-cubic yard bucket. It has 110 feet of 1¼-inch, plough-steel, 6-strand, 19-wire Lang-lay drag cable with wire-rope center. The hoist cable is 220 feet long, 7/8-inch diameter, 6-strand, 19-wire, plough-steel, regular-lay with hemp center.

This machine operated 4,200 hours during 1931 and consumed 34,224 gallons of distillate, or 0.10 gallon per ton of sand and gravel mined. The distillate for this machine is pumped from a special tank mounted on top of the locomotive tender. The price as of January 1932 was 2½ cents per gallon. The operating cost per ton with this machine is considerably less than with the steam machine and for that reason it is used more. At present, only one of these machines is used, but during the height of summer business both machines are operated on the river deposit.

HAULAGE

After being stripped, the sand and gravel are loaded into railroad cars and hauled to the washing plant by steam locomotives. Two 90-ton locomotives pull empty cars from the railroad to the dragline, a distance of 3½ miles. After the cars are loaded they are hauled 2½ miles over a level track to the washing plant, where they are emptied and refilled with washed material. They are then hauled 1 mile up a ½ per cent grade to the main line of the railroad for delivery to the consumer. A third locomotive, weighing 80 tons, is kept in reserve to replace either of the others when laid up for repairs. During the year the locomotives worked 7,380 hours and consumed 9,990 barrels of fuel oil, or 0.0292 barrel per ton of sand and gravel mined.

PLANT

Figure 3 shows a flow sheet of the plant.

The sand and gravel are loaded into drop-bottom cars and transported to the plant hopper which is 15 by 30 feet in horizontal section, is built of concrete, and has a capacity of 150 tons. A horizontal grizzly made of 60-pound rails, inverted, and spaced with 4-inch clearances, covers the entire top of the hopper. The material through the grizzly is fed by a 30-inch plate feeder to a 30-inch main conveyor belt which delivers it to the scrubber section. The plate feeder is driven from the tail pulley of the main conveyor by chain and sprocket. It has a speed of 60 r.p.m. and a throw of from 3 to 7 inches which may be regulated to suit requirements. The main conveyor belt is 185 feet between centers and is supported on an incline of 15 degrees by timber framework. This belt is driven 250 f.p.m. by a 30-hp. ball-bearing motor making 1,200 r.p.m. The belt is made of 5-ply 32-ounce duck with 1/8-inch rubber top and 1/16-inch rubber bottom. Any material that passes the grizzly but is too large for commercial use is thrown off the belt by hand into a 12-inch jaw crusher set to crush to 2 inches and operating at 600 r.p.m.

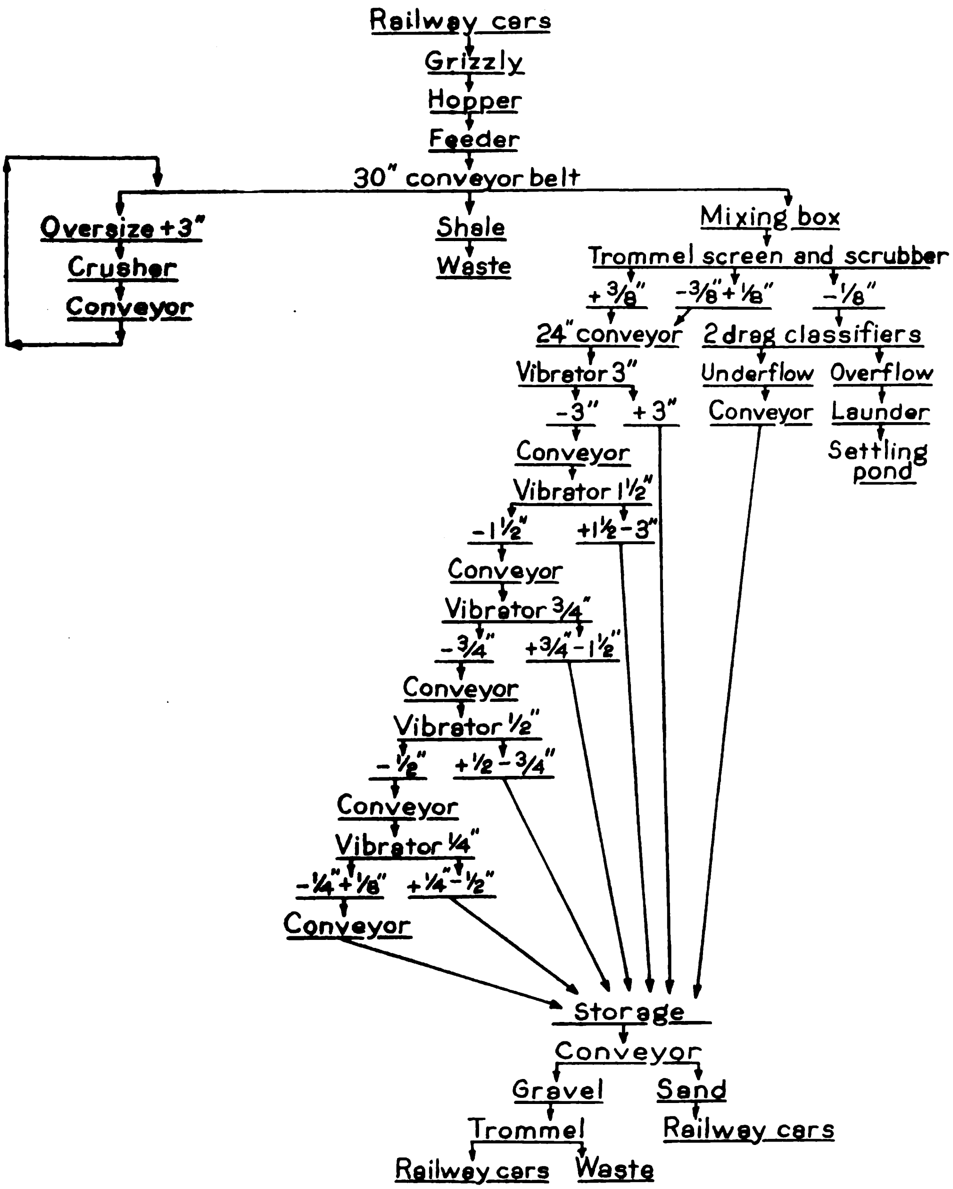

Figure 3.- Plant flow sheet

The crusher discharges onto a 16-inch inclined conveyor belt which carries the crushed material back onto the main conveyor. The crusher and 16-inch conveyor are belt driven by a 15-hp. motor making 1,200 r.p.m.

Lumps of shale that have been dug up by the draglines are picked off the belt by hand and piled on the ground until there is a carload, when they are picked up by a small clamshell and loaded into cars or trucks and hauled to waste piles. The quantity of shale or oversize is small and gives practically no trouble.

The conveyor belt delivers to a mixing box 50 feet above the bottom of the hopper. This box, 4 feet square and 3 feet deep, is made of wood and lined with steel plate. An 8-inch stream of water discharging into it mixes the material and washes it through an opening into the main washing screen. The water is supplied from a pond 75 by 100 feet dug a short distance away. This pond is about 15 feet deep, and the natural flow of ground water into it is supplemented by using the wash water over again after the silt has settled. An 8-inch centrifugal pump driven by a 50-hp. ball-bearing motor forces 1,200 gallons per minute into the mixing box.

The pipe from the main pump has a horizontal length of 400 feet and a vertical rise of 40 feet, making a total head of approximately 115 feet. The pressure gage at the pump registers an average of 40 pounds per square inch.

The main screen is a heavy-duty cylindrical scrubber, which is 6 feet in diameter and 20 feet long. It is equipped with trunnion bearings, is inclined at 3° and makes 30 r.p.m. The first 5 feet is a solid scrubber section with baffles which break loose all particles stuck together. The baffles are made of 3-inch angle iron and are set 3° out of line with the screen axis. The next 15 feet is made up of ¼-inch steel plate perforated with 3/8-inch round holes. Surrounding the screen is a sand jacket of wire cloth with 1/8-inch square openings. This jacket is 6½ feet in diameter and 15 feet long.

The proportion of material passing over and through the various screens of the trommel has never been determined. Ordinarily the 3/8-inch screen lasts one year while the sand jacket has to be renewed at the end of six months. The sand and water passing the sand jacket are flumed to two sand classifiers of the drag type, constructed of wood with three railroad rails in the bottom of the tank to take the wear of the flight plates. Each box is 5½ feet wide inside and has a flat-bottomed section 10 feet long and a 15-foot section with the bottom inclined at 20°. Two lengths of No. 830 chain have attachments at every other link for carrying the flight plates, which are made of 3/8-inch steel, 5 feet long and 6 inches wide. These two chains are set on 25-foot centers. The plates are spaced at 1-foot intervals and travel 25 feet per minute. Each drag is operated by a 15-hp. ball-bearing motor making 1,800 r.p.m. and transmitting power through spur gears and a chain drive in oil.

The water flows out one end of the classifier to the settling basin, and the sand is dragged to the other end, deposited on a 24-inch conveyor belt, carried to the top of the plant, and dropped onto the first storage pile.

It is difficult to determine the tonnage handled by each of these drags, as at times the material from the pit will not contain much sand and one drag is operated without the other. At other times the flow of material is reduced while one of the drags is being repaired. If both drags are running they each handle one-half of the sand. The parts on these sand drags wear rapidly. Where the flight plates wear on the rails in the bottom of the tanks, thereby cutting a groove in the flights, they are repaired with a piece of ½ by 6 by 6 inch steel plate, drilled with two holes through the center line and bolted so that when one side wears out they can be reversed. The drag chain is of the link, bushing, and pin type, and will last a year if the bushings are properly renewed when worn. The sprockets for this chain are made of manganese steel, having 10 renewable, reversible teeth. These sprockets will last a year.

Both sand drags deposit sand on the same conveyor. This conveyor is 172 feet between centers, is inclined at 15°, and is driven through gear connection by a 15-hp. ball-bearing motor making 1,800 r.p.m.

This conveyor and all the other belts in the plant, with the exception of the main conveyor belt, are 24 inches wide, and are made of 5-ply 32-ounce duck with 1/8-inch rubber top and 1/16-inch rubber bottom. The short belts are all driven by 5-hp. ball-bearing motors, through gear connection.

All sizes of material above 1/8 inch are discharged from the end of the cylindrical screen onto a belt conveyor and carried to the top of the plant for sizing and distribution to storage piles. The gravel is conveyed by a series of short belt conveyors, 55 to 65 feet long to a series of 6 vibrating screens, 4 by 7 feet, and inclined at approximately 40°. The screens on these vibrators will last from 6 to 15 months, depending on their mesh size. The larger screens wear out more quickly as they carry a larger load. At each successive screen the oversize is screened out and carried to storage, and the undersize goes to the next screen. Wire screens are used on these vibrators, the size of openings beginning at 3 inches and diminishing to 1½, ¾, ½, and ¼-inch, making sizes of gravel as follows: 3 to 1½ inches; 1½ to ¾ inch; ¾ to ½ inch; ½ to ¼ inch; and ¼ to 1/8 inch. The last size is added to the sand in proportions to meet specifications for concrete sand.

Some sizes, notably brick sand, ¾ to ½ inch gravel, and ½ to ¼ inch gravel are made in excess quantities, especially during the winter months. A slack-line cableway drags this surplus away from the plant in the direction indicated by arrows on the plan (fig. 4). These materials are reclaimed by reversing the cableway bucket. This storage is necessary because of the seasonal demand for the fines.

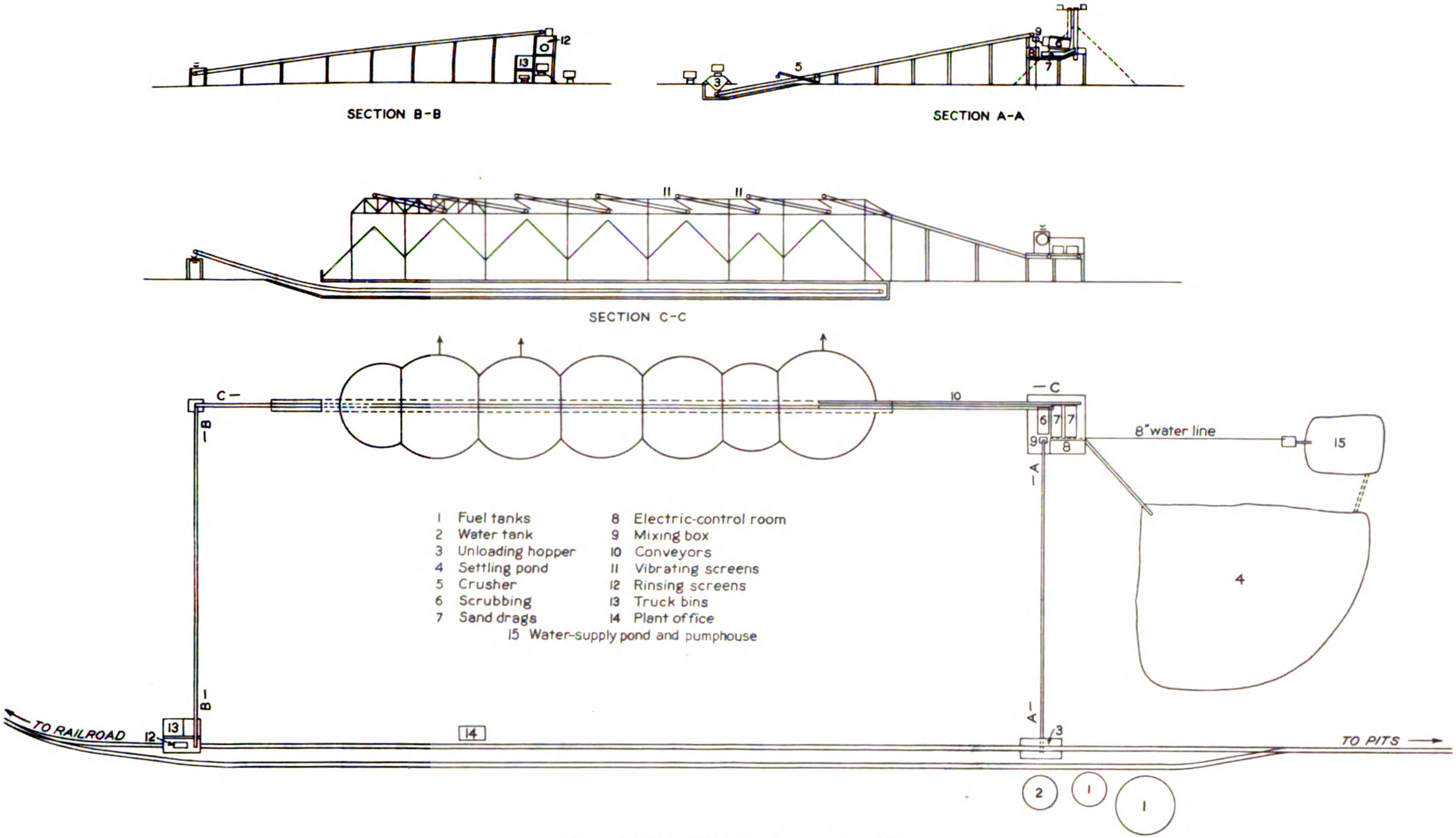

Figure 4.–Plan of Quigley plant, Hart Spur, Tex.

The cableway is equipped with a bottomless, ½-yard bucket, pulled by a 3/8-inch plough-steel cable at a rate of 100 f.p.m. The track cable is ½ inch. Both cabled last about one year. The cableway is powered with a 15-hp. motor, gear-connected to the drag and reverse drums.

A subsidiary company making cold-mixed asphalt buys a considerable quantity of the fines. They are also shipped to the central concrete plant of the company, where they are used in concrete mixes whenever possible. These two plants take considerable material the disposition of which would ordinarily be a problem.

The plant will easily wash and store 250 tons of material per hour. The storage will hold over 30,000 cubic yards without dragging any material away from the plant. The scraper more than doubles this storage capacity.

The storage piles are directly on the ground and there is no division wall between them. Such division is unnecessary because the gravel and sand are drawn from the center of the storage piles and the angle of repose does not permit one grade of material to flow to the gates underneath the adjoining pile, even if the latter is low.

A loading-out tunnel 7 by 7 feet inside and 400 feet long traverses the entire length of the storage piles. Under each stock pile are three or four 16 by 16 inch manually operated clamshell gates for drawing the material onto a 24-inch conveyor belt which is 475 feet between centers. This conveyor is horizontal through the length of the tunnel, then rises about 12 feet in a distance of 36 feet. The gravel travels out of the tunnel onto an inclined 24-inch conveyor belt (see section B-B, fig. 4) which carries it to the top of the loading tipple. The tipple belt is inclined about 15° and is driven by a 10-hp. ball-bearing motor, gear connected. The belts are of the same construction as the other 24-inch belts. The speed of the tunnel belt is 250 f.p.m., but that of the tipple belt is increased to 275 f.p.m., as a greater load is deposited on the horizontal tunnel belt than can be carried by the inclined tipple belt at the same speed.

The grading of the gravel is done on the tunnel belt; that is, the various sizes are put on the belt in the proportions necessary to meet specifications. Two men are required in the tunnel to proportion the material and to prevent bridging above the gates. Only a short time is required to train a man to adjust the gates to get the correct gradings. The plant foremen looks after the grading personally and checks it by making screen analyses, taking his samples from the car-loading chute. At the loading tipple the sand is dropped directly into the railroad cars through a flop gate, but gravel is diverted into a cylindrical screen 4 feet in diameter and 10 feet long, where it is sprayed by a stream of water to rinse off dust that has accumulated in the stock pile. This screen makes 30 r.p.m. and is inclined at 4°. It is a trunnion-type screen of skeleton construction and is covered with ¼-inch mesh woven-wire cloth. It is belt driven from a 10-hp., ball-bearing motor making 1,800 r.p.m. The various sizes of gravel carried on the belt are thoroughly mixed by the rinsing screen before going into the car. The chute for loading cars is hinged so that it can be swung from one side of the car to the other to prevent segregation of sizes. After loading, the cars are hauled to the railroad siding for shipment.

The washing plant consumed 247,900 kw.h. during 1931 or 0.0725 kw.h. per ton of sand and gravel mined.

Repairing of all equipment is done in the company's own machine shop under the direction of a master mechanic. The shop is equipped for all classes of repair work, except gear pressing and the turning of locomotive tires. Bushings and many wearing parts are made in the shop and a supply of them is kept on hand for making breakdown replacements.

RECOVERY

About 60 per cent of the material mined is sold as sand and gravel and 40 per cent is wasted. Of the 60 per cent saved, 24 per cent is sold as washed gravel, 18 per cent as washed sand, and the other 18 per cent as pit-run sand and gravel. The latter is used for railroad ballast and in making concrete base for streets where an asphalt or brick topping is used.

PAY SYSTEM

A monthly salary is paid the superintendent, foremen, and master mechanic. These men receive a 2-weeks paid vacation each year and bonuses on a profit-sharing basis, the rate being fixed by the board of directors. The other men are paid an hourly wage ranging from 30 to 75 cents depending on the class of work they do. The wage scale is based on a 10-hour day and 300 working days per year.

SAFETY METHODS AND FIRST-AID TRAINING

The foremen are the key men in the safety organization. A meeting is held once a month at which a man furnished by the underwriters of the company's liability insurance gives a talk on safety methods. He has divided the men into two groups for "no-accident competition." The competitive plan has proved most satisfactory and especially so when encouraged by company officials.

ADMINISTRATIVE ORGANIZATION

The organization chart, Figure 5, correlates each department, and shows the average number of men in each. The pit superintendent handles all production and maintenance matters, acting with the vice-president in an advisory capacity.

Table 1.- Summary of Costs

Hart Spur pit Period: January 1 to December 31, 1931.

Overburden removed .... tons 288,000 (estimated)
Sand and gravel loaded ... do 341,633
Sand and gravel washed ... do 288,279

Cost per dry ton of sand and gravel mined

	Labor	Supervision	Power	Fuel	Supplies	Total
Stripping and mining	$0.0323	$0.0123	-	$0.0034	$0.0110	$0.0590
Track maintenance	.0289	.0047	-	-	.0071	.0407
Transportation	.0050	.0010	-	.0195	.0040	.0295
Pit maintenance	.0055	-	-	-	.0260	.0315
Washing plant	.0481	.0073	$0.0207	-	.0082	.0843
Plant maintenance	.0053	-	-	-	.0157	.0210
Total direct operating cost	0.1251	0.0253	0.0207	0.0219	0.0720	0.2660
Depreciation	-	-	-	-	-	.0630
Depletion	-	-	-	-	-	.0216
Total operating cost	-	-	-	-	-	0.3506

Washing-plant operating cost based on tons washed

	Labor	Supervision	Power	Fuel	Supplies	Total
Washing plant	$0.0568	$0.0083	$0.0245	-	$0.0097	$0.0993
Plant maintenance	.0062	-	-	-	.0186	.0248
Totals	0.0630	0.0083	0.0245	-	0.0283	0.1241

Table 2.- Summary of Costs in Units of Labor, Power and Supplies

Hart Spur pit Period: January 1 to December 31, 1931.

Overburden removed .... tons 288,000 (estimated)
Sand and gravel loaded ... do 341,633
Sand and gravel washed ... do 239,279

A. **Labor**: (man-Hours per ton)	Stripping	Mining	Crushing	Total per ton of sand and gravel loaded
Loading	0.034	0.044	-	0.073
Transportation	-	.043	-	.043
Plant	-	-	.031	.026
Supervision	-	-	-	.009
Total	0.034	0.087	0.031	0.151

Average tons per man per shift 65.8
Labor, per cent of total operating cost 42.8

B. **Power and Supplies**: (per ton of sand and gravel loaded)

Dragline, distillate .... gal. 0.1002
Locomotive, fuel oil .... bbl. 0.0292
Washing plant .... kw.h. 0.0725

Fuel and power, per cent of total operating cost 12.0

Table 3.- Detailed Average Dragline Costs

Hart Spur pit Period: January 1 to December 31, 1931.
Monighan dragline, 3-cubic yard bucket.

Overburden removed	tons	288,000 (estimated)
Sand and gravel loaded	do	341,633

	Sand and gravel (341,633 tons)		Overburden (288,000 tons)		Total (629,633 tons)		Total cost per ton of sand and gravel
	Amount	Cost per ton	Amount	Cost per ton	Amount	Cost per ton	
Engineers	$1,950.00	$0.0057	$1,300.00	$0.0044	$3,250.00	$0.0051	$0.0095
Firemen	1,540.00	.0045	1,110.00	.0038	2,650.00	.0042	.0077
Foremen	2,520.00	.0073	1,680.00	.0058	4,200.00	.0061	.0123
Pitmen	1,465.00	.0043	975.00	.0034	2,440.00	.0039	.0072
Other labor	1,620.00	.0047	1,080.00	.0037	2,700.00	.0043	.0079
Total operating labor	9,095.00	0.0265	6,145.00	0.0211	15,240.00	0.0236	0.0446
Fuel	698.33	0.0022	465.55	0.0016	1,163.88	0.0018	0.0034
Grease and supplies	2,254.55	.0061	1,500.00	.0052	3,774.55	.0059	.0110
Total supplies ..	2,952.88	0.0083	1,965.55	0.0068	4,938.43	0.0077	0.0144
Shop labor	1,145.52	0.0033	760.00	0.0026	1,905.53	0.0030	0.0055
Repair supplies ...	5,373.94	.0158	3,520.00	.0122	8,893.94	.0141	.0260
Total repairs ...	6,519.46	0.0191	4,280.00	0.0148	10,799.46	0.0171	0.0315
Total dragline ..	18,567.34	0.0539	12,390.55	0.0427	30,977.89	0.0484	0.0905

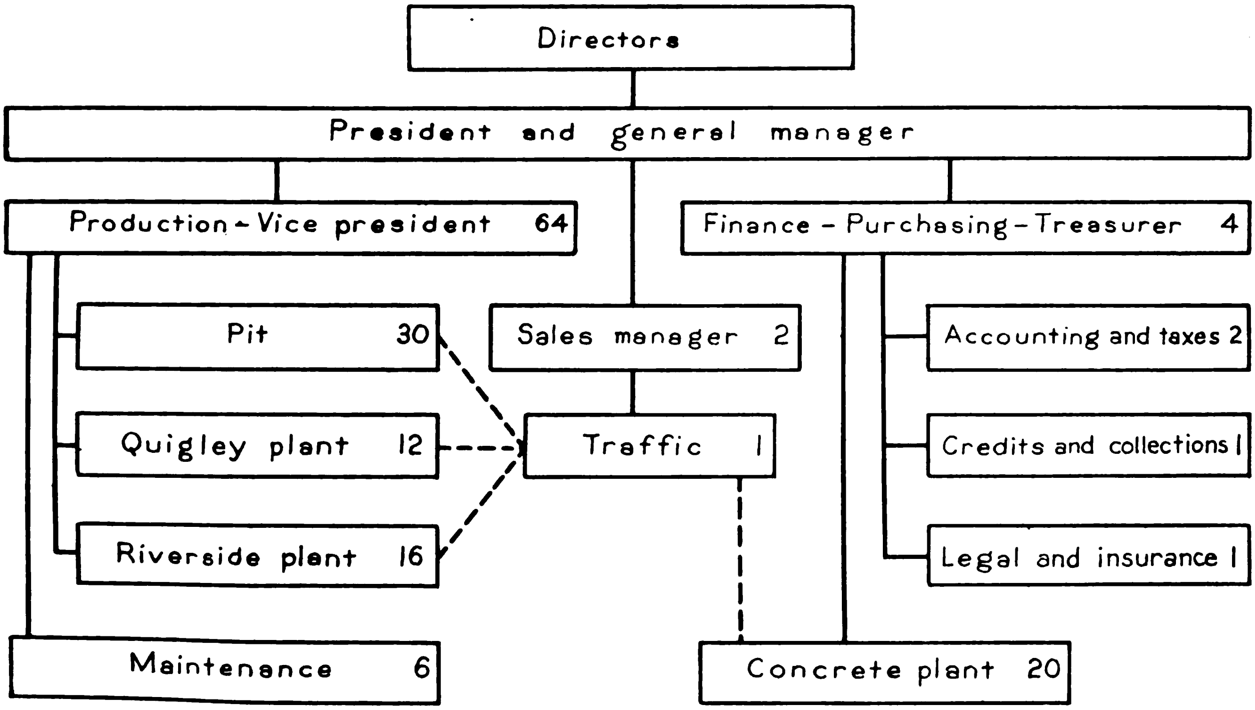

Figure 5.- Organization chart

Original from THE OHIO STATE UNIVERSITY